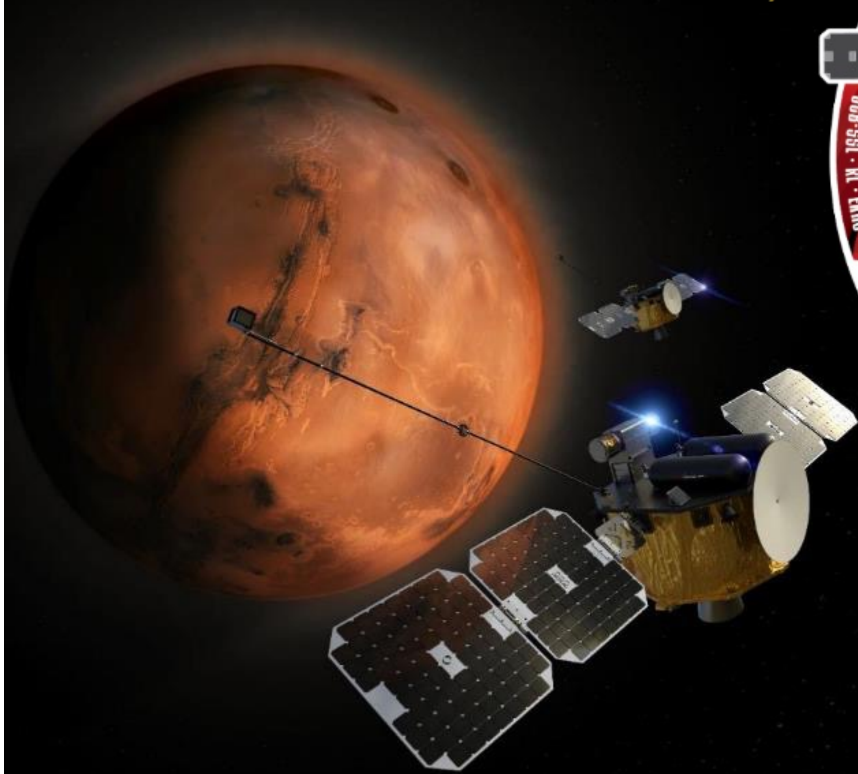


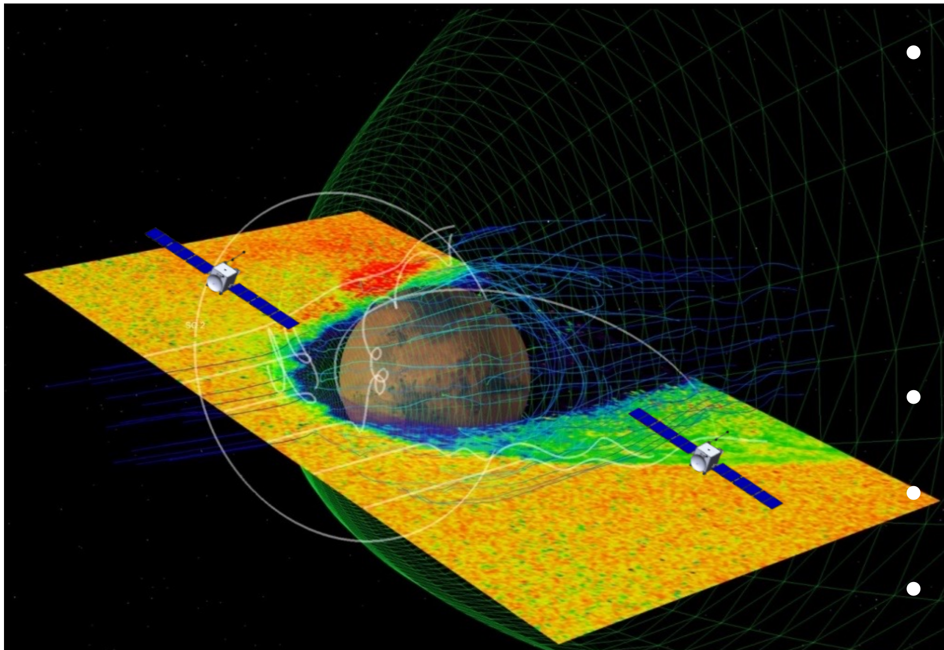
ESCAPADE Lessons Learned

Rob Lillis, ESCAPADE PI, UC Berkeley

"What would I tell Fall 2019 Me?"

November 7, 2023

What is ESCAPADE?

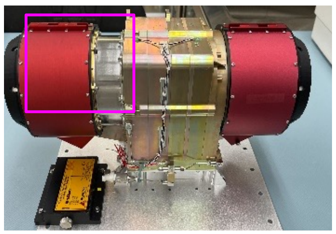


Simulation by R. Modolo

- ESCAPADE is a twin-spacecraft mission dedicated to studying the transfer of solar wind energy and momentum through Mars' unique hybrid magnetosphere and how it drives ion and sputtering escape.
- \$57M PIMMC, Class D tailored risk posture.
- Launch & (most) DSN costs covered by NASA
- Funded by NASA Heliophysics Division
- Managed by Explorers Office (GSFC)

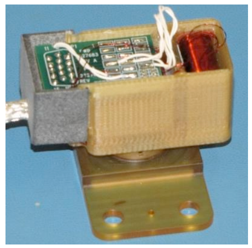
ESCAPADE Instruments, Mission & Spacecraft

EESA-i



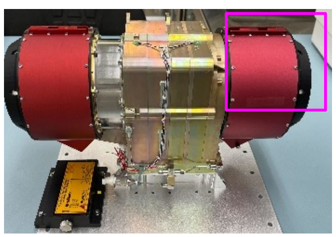
R. Livi (UCB-SSL)
Suprathermal ions

EMAG



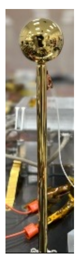
J. Espley (GSFC)
Magnetic Field

EESA-e



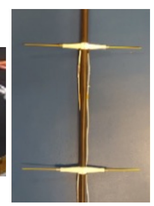
P. Whittlesey (UCB-SSL)
Suprathermal electrons & magnetic topology

ELP



FPP

PIP x 2

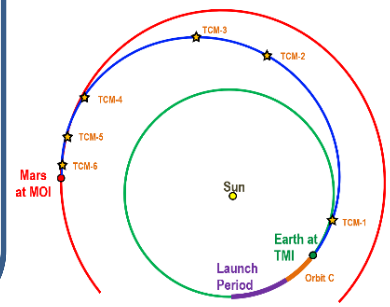


mNLP

A. Barjatya (ERAU)
Thermal plasma

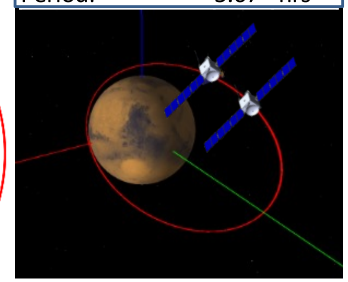
Launch	08/2024
Orbit Insertion	09/2025

~1 year transfer to Mars



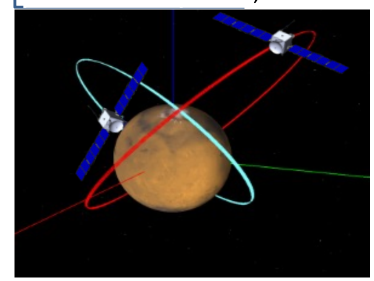
Science Campaign A
4/1/26 – 10/1/26

Periapse:	160	km
Apoapse:	8400	km
Inclination:	65	deg
Period:	5.67	hrs

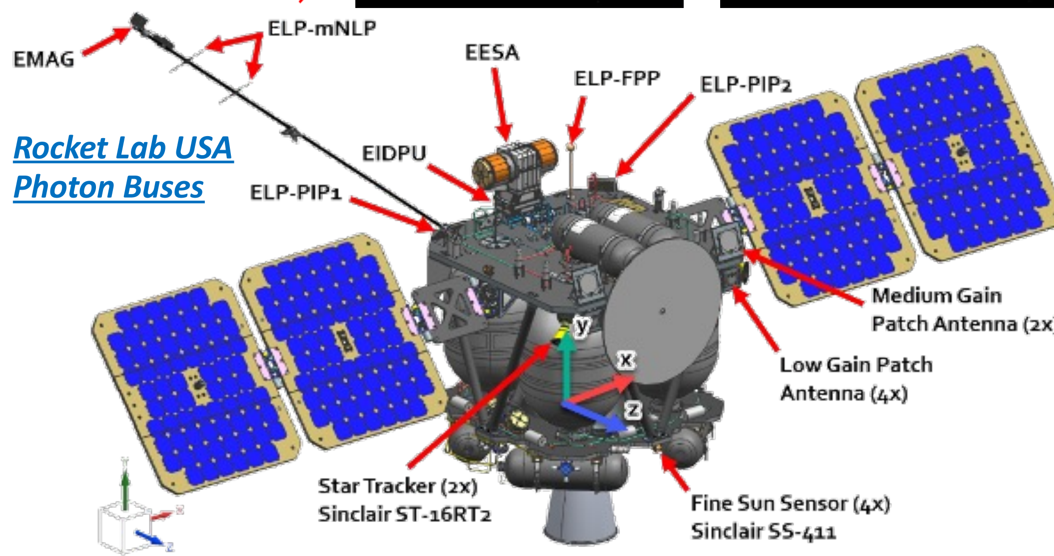


Science Campaign B
10/1/26 – 3/1/2027

Periapse alts:	160,	160	km
Apoapse alts:	10,000	7000	km
Inclination:	65,	65	deg
Periods:	6.58,	4.91	hrs

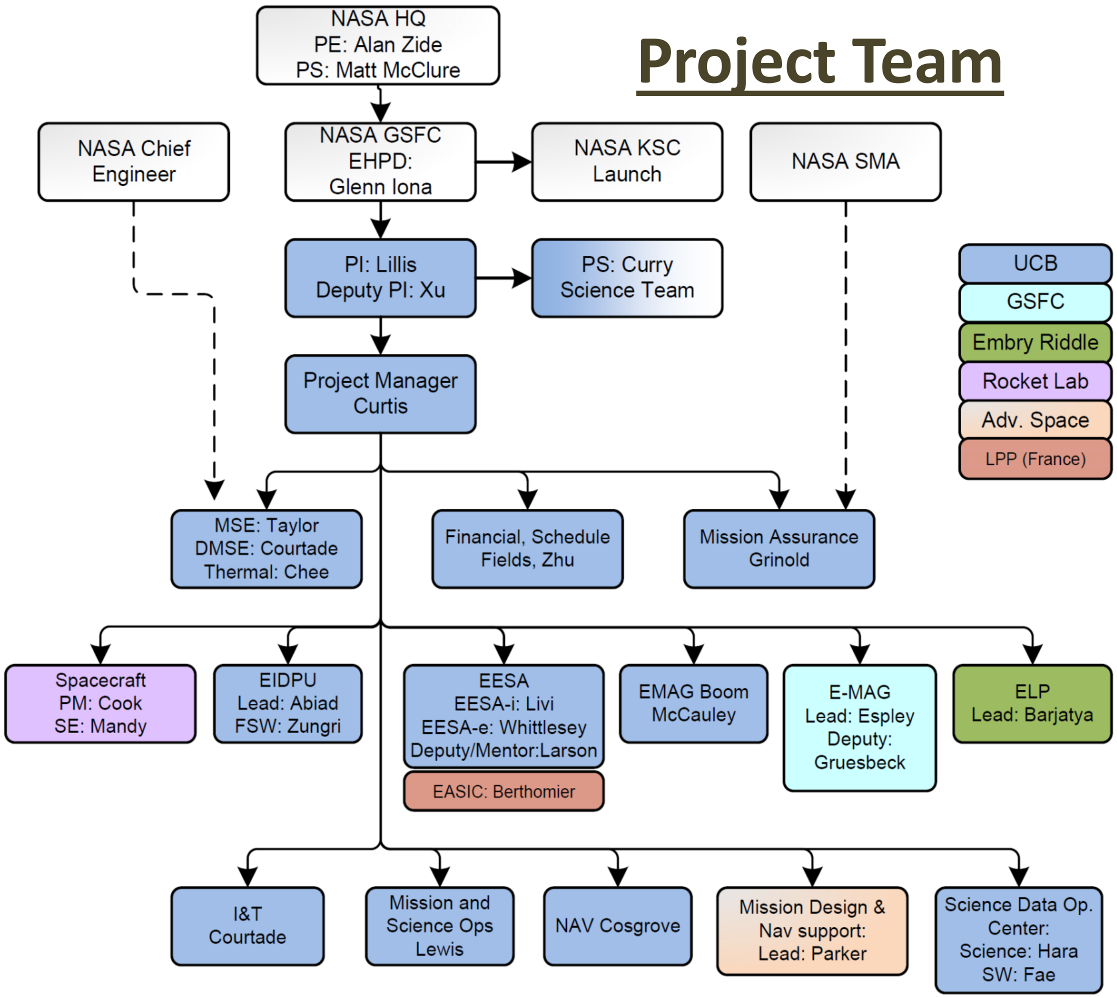


Rocket Lab USA Photon Buses

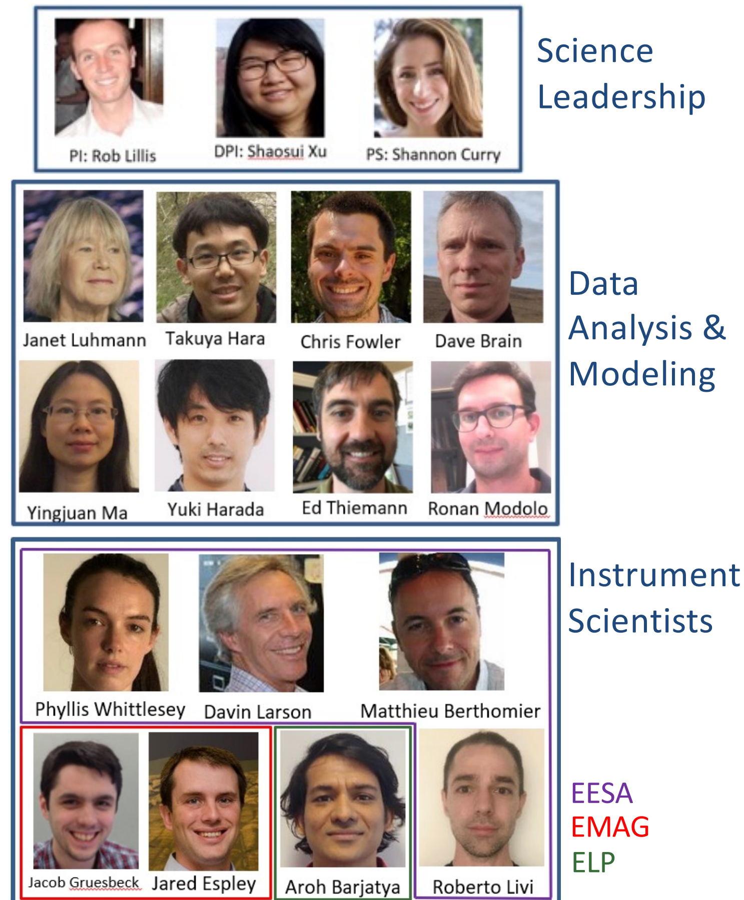


ESCAPADE Team

Project Team



Science Team



What lessons/advice will be helpful?

Relevant Experience

- Team communication.
- Managing Science Team.
- Managing SC Provider.
- Phase A/B Lessons Learned
- Phase C/D Lessons Learned
- Management Style & Decision-making.
- Conflicts & Team Dynamics
- Relationship with NASA
- Dealing with media

Maybe Not as Relevant

- $57M Cost Cap constraints
  - Very Simple instruments. Yes
  - New-entrant SC provider. Yes
- Very low data rates Yes
  - Resolution, cadence, compression, downlink delays.
- Planetary Protection Req'mts Yes
- Earned Value Management No
- Phase A competition No

What lessons/advice will be helpful?

<u>Relevant Experience</u>

- Team communication.
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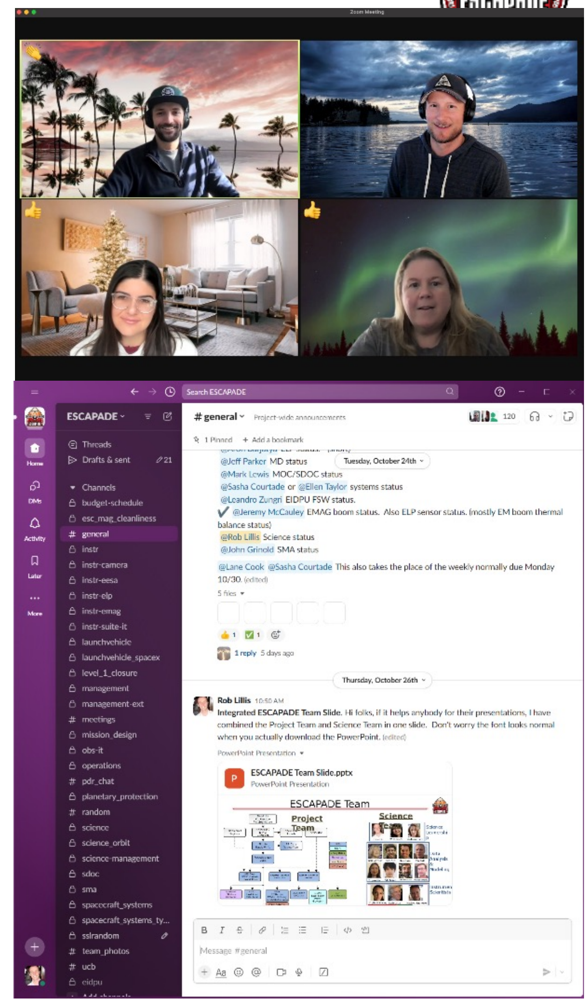
- Phase A/B Lessons Learned
- Phase C/D Lessons Learned
- Management Style & Decision-making.
- Conflicts & Team Dynamics
- Relationship with NASA
- Dealing with media

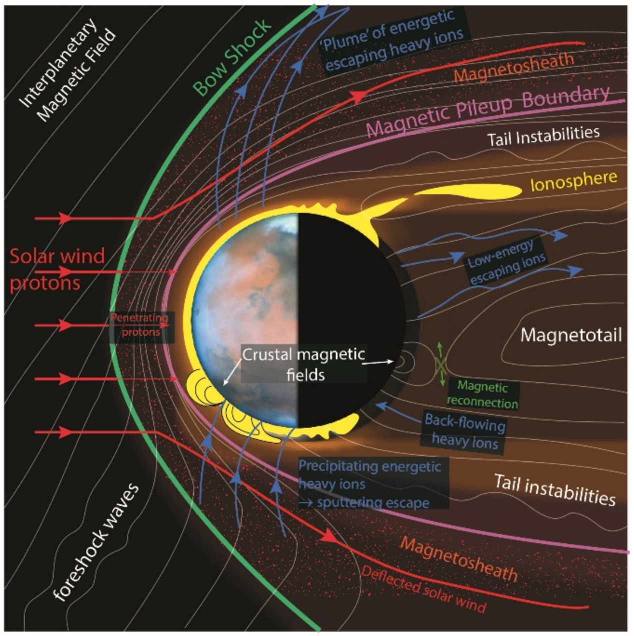
Team Communication

- 3 Fs of communication: Frequent, Frank, Focused.
- Weekly management meetings: **Monday mornings**.
  - Status, issues, plans. Safe space to discuss strategy, concerns, even rumors. Limited participation.
  - Touch all aspects: contracts/budgets, schedule, science/ data, instruments, spacecraft/systems, launch, ops, SMA.
  - PI/DPI/PS should attend. Try never to miss these.
- Give subsystem leads freedom ((bi)weekly vs. monthly)
- Slack (or Teams): Birdseye view for PI/PM.
  - Allows rapid iteration/clarification on specific topics.
  - Invite everybody in your org chart.
  - Recommend keeping channels private (cuts down on noise)
- Use email when appropriate:
  - Communications outside the team (NASA HQ/GSFC/KSC, media, vendors, admin).
  - Sensitive items (e.g. budget docs).



Managing your Science Team

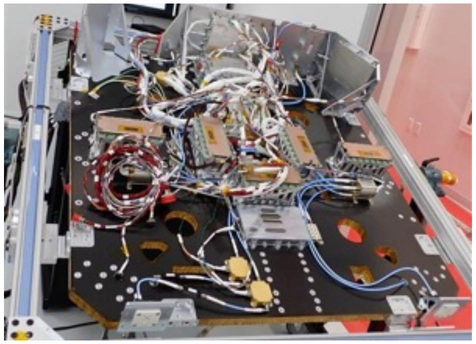
- Give DPI and PS real responsibilities.
- Clear role for all team members (1-1 convos)
- Topical Working Groups focus minds.
- Phases A/B will be busy
  - L1 Requirement Development.
  - Requirement Traceability (verification analyses)
  - Algorithm Development (if needed).
- Be respectful of team members’ time.
  - Only pull in necessary people for specific tasks
  - Advanced notice of deadlines, review dates etc.
  - Monthly science team Zoom meeting/updates
  - In person meetings: have clear goals



Managing your Spacecraft Provider

Note: modify below if SC provider is managing the project

- They are your partner but also (prob) a for-profit company. Are project & company aligned?
- PSE/PM should be always be aware of status/problems and continually track SC risks, including vendors.
- Make sure the SOW is detailed and clear!
- You will have to negotiate with their BD/execs.
  - Push back on unreasonable demands/prices.
  - NASA can be your “bad cop” if necessary.
- Contract Type: Firm Fixed Price (FFP) vs. Cost-Plus (CP)
  - **CP** works with high heritage, large technical & schedule margins, healthy cost reserves.
  - **FFP** works well if some technology unproven **<u>and</u>** company is both financially stable and won’t walk away, i.e. committed.

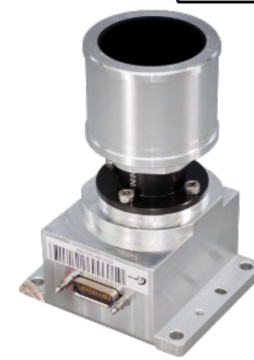


Avionics Side of Blue Top Deck at Rocket Lab

Thruster Hot Fire Test

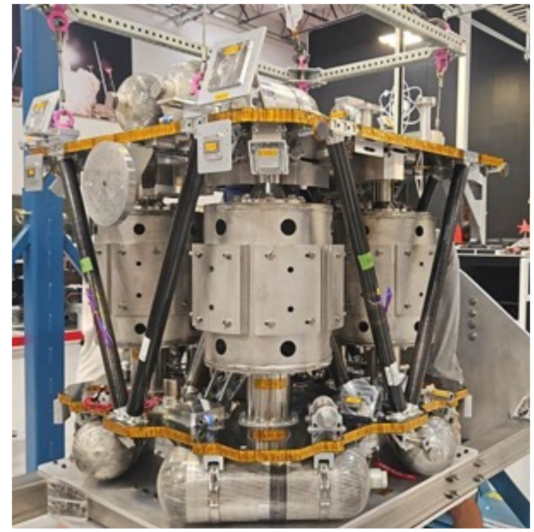
ESCAPADE Phase B Lessons Learned

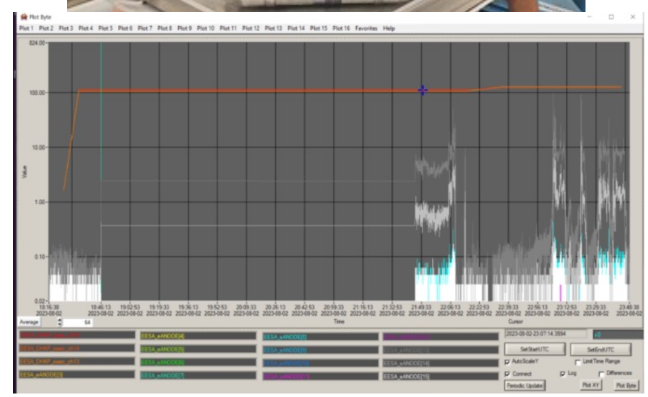
1. **Development Cycle Mismatch.** ‘Newspace’ commercial vendors’ business model of rapid iteration is *not always compatible* with NASA projects.
2. **Parts are still not cheap or quickly available**. While Class D Tailored is compatible with COTS subsystems re: reliability, COTS falls short w.r.t. e.g. Radiation Tolerance
3. **Launch uncertainty hampers system/mission design.**
   - Extra design work to evaluate range of launch targets.
   - Mission Design uncertainty flows to:
     - Propulsion system & fuel mass requirements. Overall system mass.
   - Contamination Control:
     - How clean is the fairing environment? Is N2 purge available?
   - Smallsat has to live with whatever is available but still meet its requirements: can be a Catch-22.



ESCAPADE Phase C/D Lessons learned

1. **<u>Compressed Schedule Impacts</u>**: to achieve cost reductions by shortening schedule, ESCAPADE took some risks in instrument (and spacecraft) development.
   – Reduced EM development and flight subsystem test campaign.
   – Saves schedule, but significantly increases the risk of discovering problems late in flow.
   – **Lesson: Maintain additional schedule margin at the end (some part of the time saved) to resolve the late issues.**
2. **<u>Heritage resides in the team</u>**.
   – There is hidden expertise in the team that is not well documented. MCP screener technician left, new tech did not detect MCP noise issue until calibration.
   – **Lesson: document all procedures, particularly "specialist" processes.**





Management style and Decision-making

- PI-led mission: the buck stops with you.
- Don’t manage the “how”: let your PM/SEs & other technical folks do their jobs.
- Sometimes only the PI can get things “unstuck”
- Big decisions (PI only) affect/change:
  - Org chart (i.e. key personnel & partners).
  - Science Measurements (e.g. descopes, mission design).
  - Budgets (trading off cost vs. risk).
- On big decisions, ask lots of questions, trust your people & postpone if need more analysis.

Managing Conflicts & Team Dynamics

As PI, your leadership will set the tone for the entire team. Approach conflicts with understanding, transparency, and a focus on the collective mission.

1. **Understand Technology's Role**:
   – As a PI, be aware of how tools and technologies shape team interactions. Ensure they facilitate, rather than hinder, collaboration and understanding.
2. **Champion Diversity**:
   – Actively promote diverse viewpoints in your team. Encourage open sharing, but be prepared to mediate when perspectives clash.
3. **Reinforce Shared Goals**:
   – Periodically remind your team of the overarching scientific objectives. When conflicts arise, refocus the team on these collective goals.
4. **Set Communication Norms**:
   – Design and uphold clear communication protocols. As a leader, ensure every team member feels heard and informed.
5. **Regularly Reflect on Dynamics**:
   – Take time to evaluate team dynamics and address potential issues proactively. Your proactive approach can prevent minor disagreements from escalating.

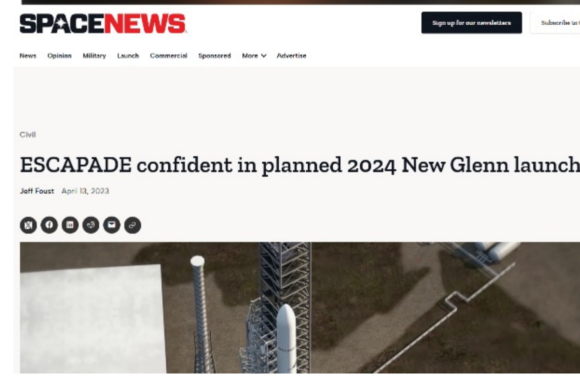
Lessons drawn from the work of Janet Vertesti. They all resonate with my experience.

Getting along with NASA

- GSFC Explorers Office
  - Mission Manager (MM) + team of 3-6
  - Contractual, financial & technical oversight
  - Provide SME help when necessary
  - Represent you at HQ.
- NASA Heliophysics Division
  - Program Scientist
  - Program Executive
  - Division Director (DD) + AD for Flight Programs.
- There to help. Your PE and PS are your NASA whisperers. Use them! Same with GSFC experts.
- Develop a relationship with the DD, but only go directly to DD when necessary.
- Keep MM, PE & PS in the loop, NASA doesn't like surprises!

Dealing with Media

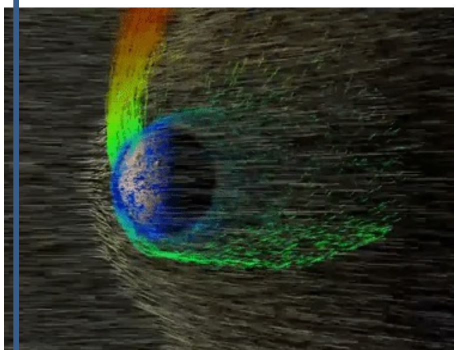
- **<u>Always</u>** run press releases past NASA PAO
- “Bursts” of press attention @ selection, confirmation, launch. You may get several interview requests.
- Translate mission science for broad audience: analogies are great. Radiate enthusiasm.
- When answering project questions:
  - Provide interesting and positive reflections on journey, partners, and NASA.
  - Repeat only what has already been made public in NASA-approved press releases.
  - Refer any launch vehicle questions to NASA LSP.
  - Do not speculate on programmatic issues.



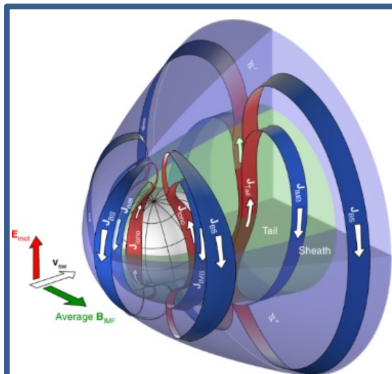
Graphic credit: UCB, Rocket Lab, and Advanced Space

BACKUP SLIDES

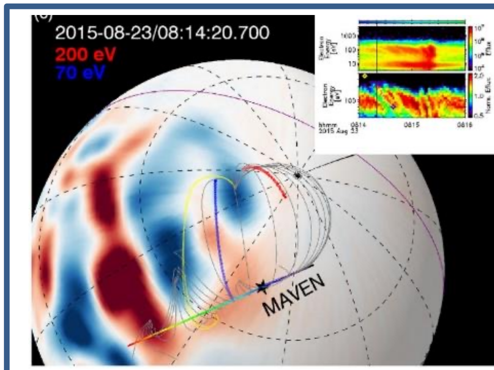
MAVEN/MEx paint "average picture" of a dynamic magnetosphere



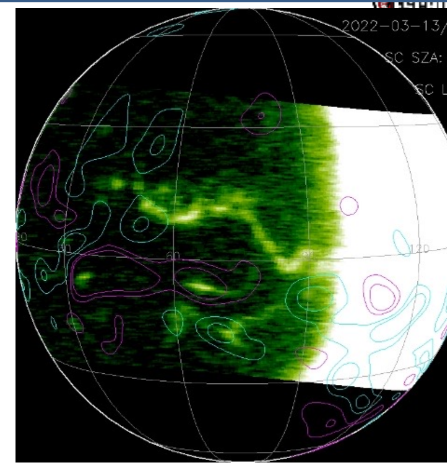
Ion escape plume
(Dong et al., 2015, 2017)



Global current systems
(Ramstad et al., 2020)



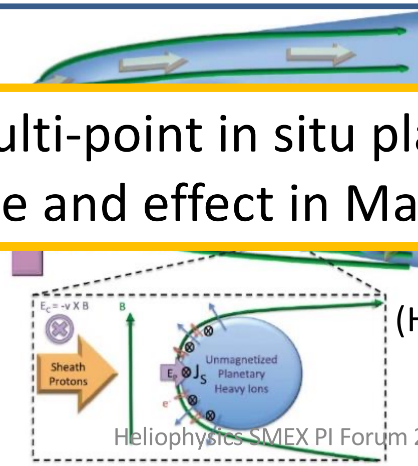
Injection & drift of electrons trapped in mini magnetosphere
(Harada et al., 2016)



Credit: EMM EMUS

Electron Acceleration →Aurora
(Xu et al., 2020)

Magnetotail twisted by crustal fields
(DiBraccio et al., 2018)



effect

(Halekas et al., 2016)

Need coordinated multi-point in situ plasma measurements to unravel chain of cause and effect in Mars' hybrid magnetosphere

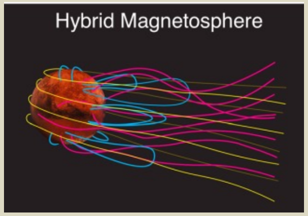
Th... (2 more) are ... nd time.
... n't distinguish ... ral variability

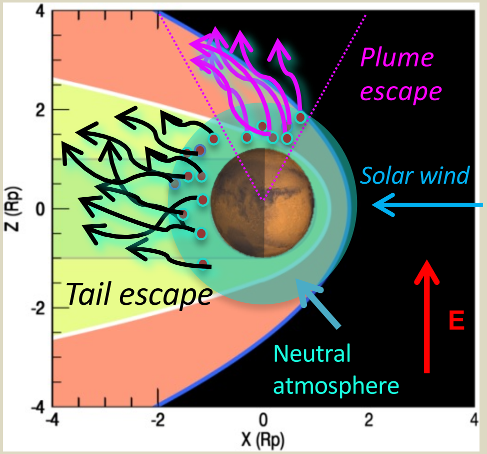
- *Cause & effect*

SW disturbances propagate through system in 1-2 mins.
MAVEN: time lag of > 1 hour.

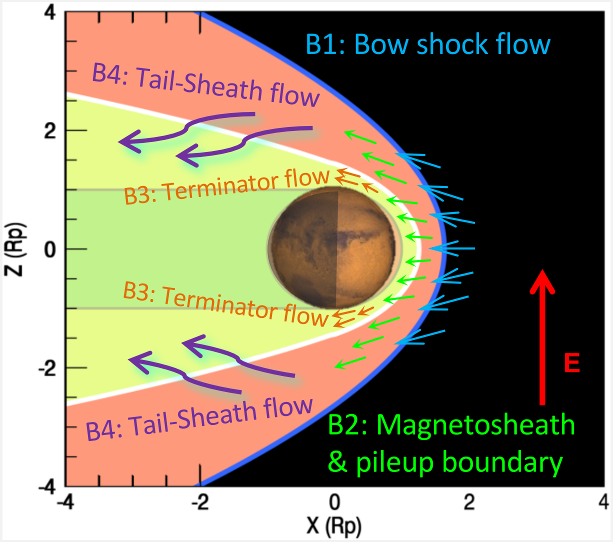
ESCAPADE Goals

***Goal A*. Understand the processes controlling the structure of Mars' hybrid magnetosphere and how it guides ion flows.**



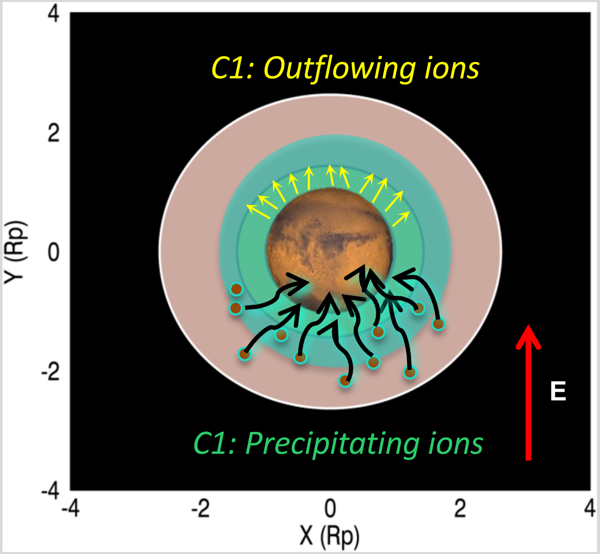


***Goal B*. Understand how energy and momentum is transported from the solar wind through Mars' magnetosphere.**



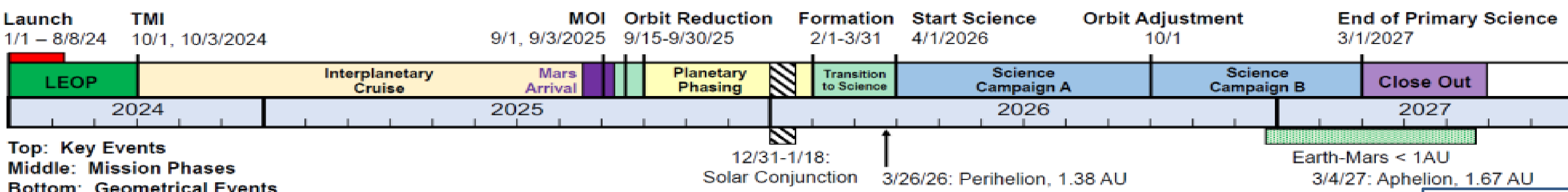
***Goal C*. Understand the processes controlling the flow of energy and matter into and out of the collisional atmosphere.**

View from Sun

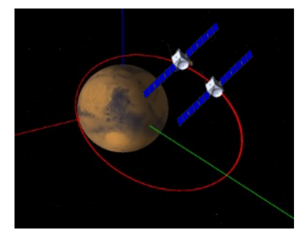


19

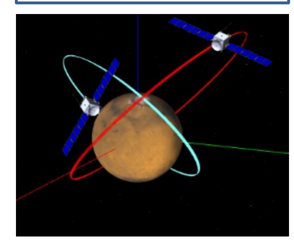
But how do you get to Mars?

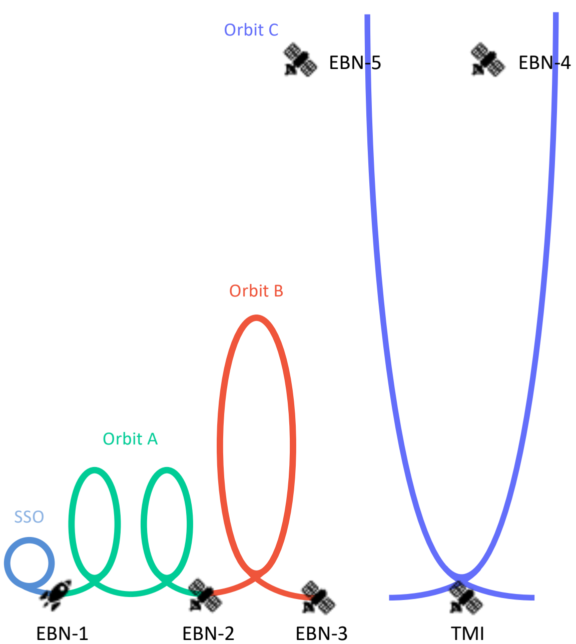


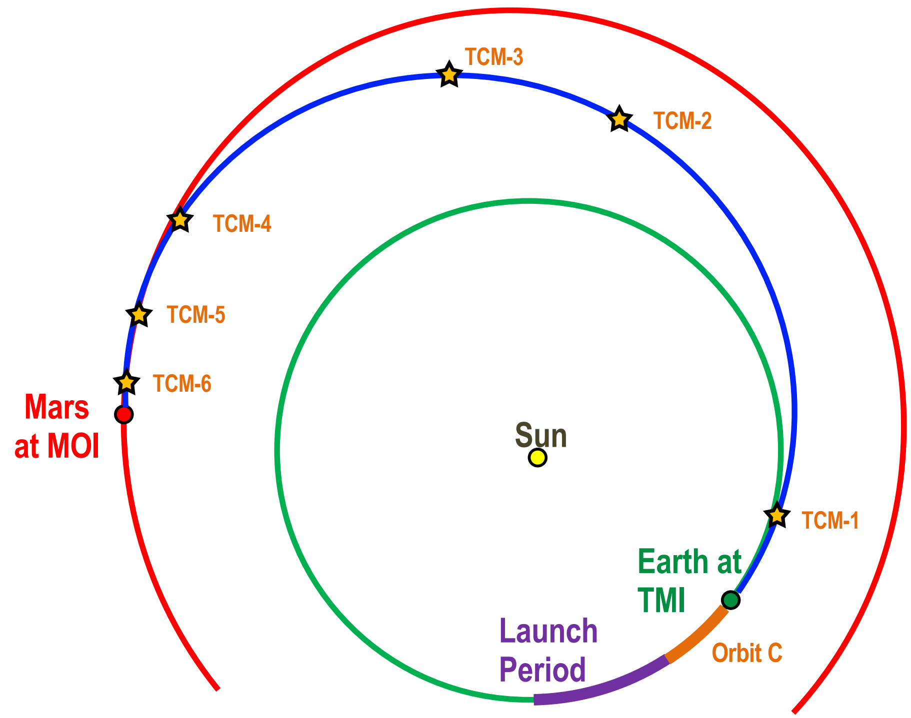
Science Campaign A	
4/1/26 – 10/1/26	
Periapse altitude:	160 km
Apoapse altitude:	8400 km
Inclination:	65 deg
Period:	5.67 hours



Science Campaign B		
10/1/26 – 3/1/2027		
Periapse alts:	160,	160 km
Apoapse alts:	10,000	7000 km
Inclinations:	65,	65 deg
Periods:	6.58,	4.91 hrs







→ to Mars

ESCAPADE Science Orbit design

Science Campaign A
4/1/26 – 10/1/26

Periapse altitude:	~160	km
Apoapse altitude:	8400	km
Inclination:	65	deg
Period:	5.66	hrs

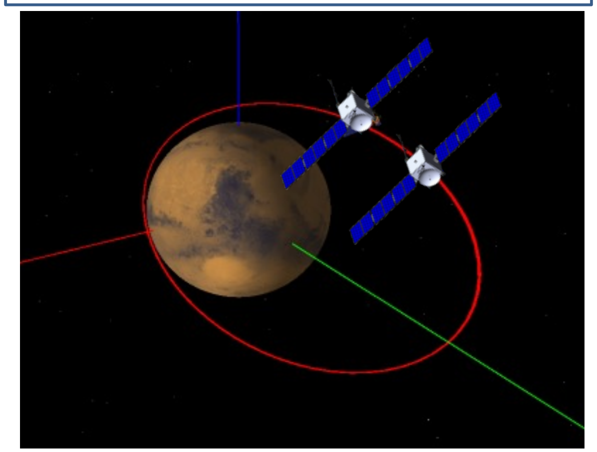
A-B Transition
October 2026

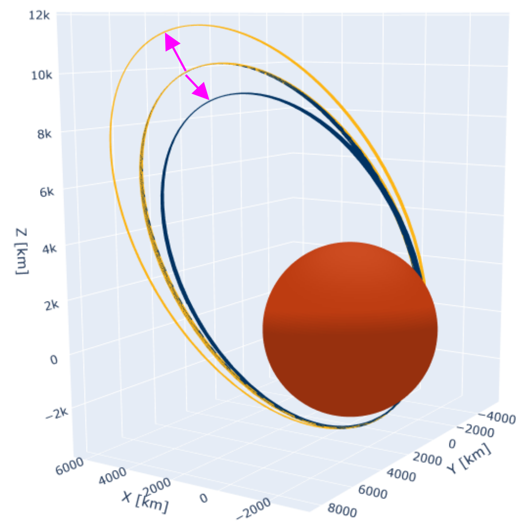
Blue ↘ apoapsis to 7,000 km

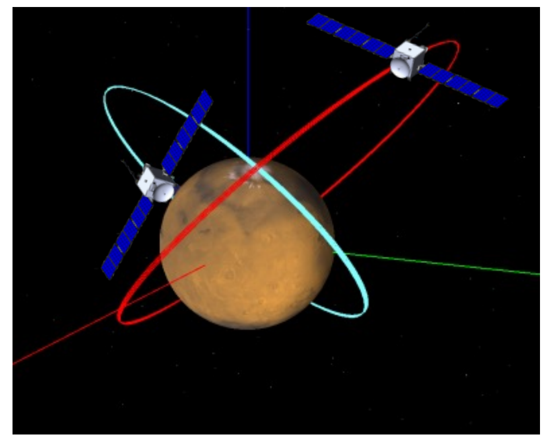
Gold ↗ apoapsis to 10,000 km

Science Campaign B
10/1/26 – 4/1/27

Periapse altitudes:	~160,	~160	km
Apoapse altitudes:	7000	10000	km
Inclinations:	65,	65	deg
Periods:	4.9	6.6	hrs







String-of-pearls:
- Optimized for studies of short-timescale variability

Orbit planes precess differentially:
- Optimized for studies of correlations between more distant regions (e.g. solar wind and ion loss in the magnetotail).

Low-cost Mars Missions are Possible!

- ESCAPADE is on track for August 2024 and is within budget.
- Valuable science can be done at low cost, IF:
  - Science goals are limited, focused
  - Instruments are high heritage
  - Transport to Mars is affordable & reliable
  - Spacecraft costs can be controlled.
  - Class D Tailoring is thoughtful.